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Advanced infantry training: an empirical analysis of (0341) Mortarman success while attending Advanced Mortarman Course

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NAVAL POSTGRADUATE SCHOOL

MONTEREY, CALIFORNIA

THESIS

ADVANCED INFANTRY TRAINING: AN EMPIRICAL ANALYSIS OF (0341) MORTARMAN SUCCESS WHILE ATTENDING ADVANCED MORTARMAN COURSE

by

Joseph P. Larkin

December 2017

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Much of a Marine's training happens on the job. Therefore, it is crucial that small-unit leaders are themselves capable and competent. In this thesis, I study the Advanced Mortarman Course (AMC), a program that trains small-unit leaders who in turn disseminate the knowledge they learned to Marines in their units who have not attended the school. In 2016, the AMC had an attrition rate of over 40 percent, which brings into question both the course content and the screening and selection process. It appears that the course content is appropriate, and so my analysis focuses on the screening and selection process. Using personnel records of students who attended the AMC between 2013 to 2014, I explore the statistical relationship between the likelihood of graduation and observable characteristics of the students. I find that General Technical scores, proficiency and conduct marks, and experience as a Marine, are significant determinants of success, while physical fitness is not. These findings can help operational commanders make better-informed decisions on which Marines should attend advanced training, thus ultimately reducing costs and increasing unit readiness.

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ADVANCED INFANTRY TRAINING: AN EMPIRICAL ANALYSIS ON (0341) MORTARMAN SUCCESS WHILE ATTENDING ADVANCED MORTARMAN COURSE

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ABSTRACT

Much of a Marine's training happens on the job. Therefore, it is crucial that small-unit leaders are themselves capable and competent. In this thesis, I study the Advanced Mortarman Course (AMC), a program that trains small-unit leaders who in turn disseminate the knowledge they learned to Marines in their units who have not attended the school. In 2016, the AMC had an attrition rate of over 40 percent, which brings into question both the course content and the screening and selection process. It appears that the course content is appropriate, and so my analysis focuses on the screening and selection process. Using personnel records of students who attended the AMC between 2013 to 2014, I explore the statistical relationship between the likelihood of graduation and observable characteristics of the students. I find that General Technical scores, proficiency and conduct marks, and experience as a Marine, are significant determinants of success, while physical fitness is not. These findings can help operational commanders make better-informed decisions on which Marines should attend advanced training, thus ultimately reducing costs and increasing unit readiness.

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LIST OF ACRONYMS AND ABBREVIATIONS

1STMARDIV	1st Marine Division
2NDMARDIV	2nd Marine Division
AFQT	Armed forces qualifying test
AITB	Advanced Infantry Training Battalion
AMC	Advanced Mortarman Course
AR	Arithmetic reasoning
AS	Auto shop
ASVAB	Armed service vocational aptitude battery
BE&E	Basic Electricity and Electronic
BIR	Basic individual record
BRC	Basic Reconnaissance Course
CAS	Close air support
CFF	Call for fire
CFT	Combat fitness test
Cpl	Corporal
CSV	Comma separated values
DIVO	Division order
DOD	Department of Defense
DOE	Date of enlistment
EDIPI	Electronic data interchange personal identifier
FDC	Fire direction center
FE	Fixed effects
FLE	Field leadership evaluation
FO	Forward Observer
FY	Fiscal year
GT	General technical
HLZ	Helicopter landing zone
ID	Identification
ITB	Infantry Training Battalion
IULTC	Infantry Unit Leader Training Company

JPM	Job performance measurement
LAR	Light Armored Reconnaissance
LARS	Left add right subtract
LCpl	Lance Corporal
LOGIT	Logistic
LPM	Linear probability model
MCC	Monitored command code
MCRISS	Marine Corps recruiting information support system
MCT	Marine Combat Training
MEF	Marine Expeditionary Force
MK	Math knowledge
MOS	Military occupational specialty
MSG	Marine Security Guard
NAVMC	Navy and Marine Corps
NCO	Non Commissioned Officers
NOD	Number of deployments
PFT	Physical fitness test
PII	Personally identifiable information
POI	Period of instruction
PRO	Proficiency
PROCON	Proficiency and conduct
PTP	Predeployment training program
Sgt	Sergeant
SNCO	Staff Non Commissioned Officer
SOI	School of Infantry
TFDW	Total Force Database Warehouse
TIG	Time in grade
TIS	Time in service
TTP	Tactics, techniques, and procedures
VE	Verbal expression
VHF	Very high frequency

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I. INTRODUCTION

> The purpose of all training is to develop forces that can win in combat. Training is the key to combat effectiveness and therefore is the main effort of a peacetime military.
>
> — United States Marine Corps (1997)

A. OVERVIEW

Competent and capable leaders are vital components in developing a proficient and cohesive unit. In an infantry battalion, advance trained Mortarmen are a precious commodity that bring a vast amount of skills, knowledge, abilities, and leadership to those in their charge. Serving as their units' primary trainers, mortar squad leader and section leaders are instrumental to increasing unit proficiency throughout the predeployment training program (PTP).

Operating in an environment with constrained timelines, tight budgets, and manning reductions, infantry commanders must be cognizant of the limited opportunities, consequences, and benefits to sending their Marines to advanced level training, specifically, the Advanced Mortarman Course (AMC). Prospective students' success is predicated on an effective command screening process that focuses on a Marine's capabilities and qualities. The endstate is to receive a more knowledgeable, competent, and effective leader on his first attempt. Data collected from 1st Marine Division (1STMARDIV) and 2nd Marine Division (2NDMARDIV) in Fiscal Year (FY) 2016 identify a potential problem with the screening and selection process. In FY 2016 1STMARDIV and 2NDMARDIV experienced an attrition rate of 41 percent and 46 percent for students attending AMC. This information drives a variety of questions pertaining to the screening process effectiveness, the qualities that aid in success, and policy implications for better use of the Marine Corps' scarce time, funding, and resources. By identifying key measures of effectiveness and determinants of success, commanders can make better informed decisions on which Marines attend in an effort to increase graduation rates and ultimately unit performance.

B. PURPOSE AND RESEARCH QUESTIONS

The purpose of this study is to gain an enhanced understanding of critical characteristics influencing a Marine's probability of success at AMC. This quantitative analysis uses empirical data collected from both East and West Coast AMCs and through regression analysis estimates a model to identify what the most significant determinants of an individual's success are and whether or not there is an optimal mix of factors contributing to that success. This analysis also focuses on identifying the impact a Marine's Time in Grade (TIG), Time in Service (TIS), and time with his unit have on graduation likelihood. Finally, I seek answers to which characteristics are most correlated with a Marine's probability of survival throughout the training cycle. The benefits of this research are to reduce school house attrition rates, reduce personnel costs, and save time and physical resources. Finally, I provide additional insight into current Marine Corps policy regarding military occupational specialty (MOS) selection.

C. SCOPE AND LIMITATIONS

The scope of this research is the student populations of past Advanced Infantry Training Battalion (AITB) East and West's, AMCs. I use data on students who attended from FY 2013 through FY 2016. This timeline provides me with data from each of the four class iterations held per FY (five iterations for AMC East in FY 2016), providing a sample size of 1,217 observations. The data focuses on cognitive, performance, and experience categories for each observation. Based on these categories, analysis using a Marine's performance records, training records, and individual demographics will determine if a statistical relationship exists between dependent and independent variables. The dependent variable in this model is whether a student graduates or fails. Independent variables include: Armed Service Vocational Aptitude Battery (ASVAB) test scores, deployment history, career duration, time with unit, proficiency and conduct (PROCON) marks, physical fitness test (PFT)/combat fitness test (CFT), age, rank, and other demographic variables.

D. METHODOLOGY

I use the data analysis and statistical software package, STATA 14.2 for this study. The study is multifaceted and employs linear probability models (LPM) and survival analysis to identify the most influential determinants of an individual's success at AMC. The first part of this study involves a series of univariate and multivariate stepwise regressions to assess the significance, impact, and predictive power of each independent variable on the likelihood of graduation. I control for class year and iteration fixed effects (FE) in all regressions to account for unobserved variables. Potential unobserved variables that may bias my results are changes in course schedules, peer effects, instructor cadres, instructional methods, and weather, terrain or seasonal effects.

The second part incorporates all variables into one LPM and assesses the effects of each variable on the likelihood of graduation.

The third part of this study focuses on survivability and uses survival analysis to identify which individual characteristics have the highest probability of impacting a Marine throughout the 38-day training cycle. I employ a Cox Proportional Hazard model to estimate the predictive nature of each covariate as Marines exit the initial state or fail the course at each training day.

E. FINDINGS

This study finds that General Technical (GT) scores, proficiency and conduct (PROCON) markings, and TIG for Lance Corporals (LCpls) are statistically and theoretically meaningful variables predicting graduation at AMC.

My first finding further supports previous research and highlights the positive relationship between GT scores and the probability of survival. It is evident through survival analysis that increased levels of cognitive ability have significant impacts on a Marine's probability to survive during AMCs most difficult training phases, to include FDC and advanced FDC evaluations. These events require a heightened degree of cognitive agility by testing a Marine's skill in generating accurate firing data using mathematical computations, elevation and distance computations, map reading, general cognitive processing speed, and precision.

My second finding indicates PROCON marking is a statistically and economically significant predictor. In the operating forces, technically competent and tactically capable Marines traditionally have higher PROCON marks, which according to these findings are correlated with a Marine's mastery of the course material, ultimately increasing the likelihood of graduation. Marines with the greatest likelihood of graduation are those who possess an average PROCON marking of 44 or above.

My third finding links the high numbers of LCpls in the sample, with the predictive power of TIG. As data reveals LCpls with less than 18 months TIG are at a higher risk of failure than those with more than 18 months. With limited TIG a Marine is less likely to grasp the concepts and skills necessary to succeed at AMC. Deferment allows operational units to better prepare and guide their small unit leaders in the execution of their duties. It also provides them with additional time and experience operating their designated mortar systems, presumably increased technical and proficiency levels.

Results from this study reinforce many of the findings in the wider body of literature pertaining to the predictive measures of success for military training. The greater majority of previous research identifies that GT scores, PROCON markings, physical fitness metrics and rifle scores are meaningful predictors of success. This study shows similar results across many of these variables, however, it highlights the difference in predictive power associated with Marine Corps standardized physical and performance metrics (CFT and rifle scores). AMC relies heavily on cognitive and MOS technical proficiency, which are elements operational commanders can use to better screen and select future candidates.

F. OVERVIEW OF CHAPTERS

This research is organized into six chapters. Chapter I provides an overview of the problem and identifies the purpose and methodology of the study. Chapter II provides background information on the Marine Corps' formal training environment, the organization's training philosophy, and in depth look at the 0341 MOS and AMC. Chapter III reviews relevant literature on training success for military service members.

Chapter IV outlines data used in this research and describes the methodology for analysis. Chapter V discusses the results and analysis of each model. The study ends with, Chapter VI, a conclusion and recommendation section.

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II. BACKGROUND

A. HISTORY OF THE SCHOOL OF INFANTRY AND ADVANCED MORTARMAN COURSE

Condit, Diamond and Turnbladh’s 1956 study, Marine Corps Ground Training in World War II, best describes the Marine Corps’ philosophy and overall reputation of being a “fighting service” who in times of crisis “sought to put the greatest possible number of men on the firing line” (p. 196). They further articulate how the Marine Corps requires “a high order of technical skills in a great variety of specialties” (p. 196) to maintain this fighting capacity. Condit, et. al’s research provides valuable contextual insight regarding the Marine Corps need for rigid and formalized training. Regardless of the century or current nature of warfare, the need for technical skills in a combat environment is essential and helps pave the way for the current AMC training environment.

In the 1940s and 1950s the Marine Corps faced considerable challenges with a major world war and later conflict on the Korean peninsula. In response to these events the Marine Corps dedicated considerable resources to develop a better, more formalized training institution built at Camp Geiger, North Carolina. It is here that advanced infantry training was born, geared towards preparing combat replacements for future deployments (School of Infantry East [SOI-E], (2017). Overseeing this training was the newly established command, the Infantry Training Regiment, that instructed all Marines in basic infantry fundamentals.

Throughout the 1960s and 1970s the Infantry Training Regiment saw considerable change in terms of its organizational structure and training duration. Organizationally, the Infantry Training Regiment experienced a split in their curriculum, providing separate, tailored training to infantry and non-infantry MOSs, a shift from the previously consolidated training curriculum. The Infantry Training Regiment’s growth skyrocketed in the early years of 1962 where upwards of 22,760 Marines graduated (SOI-E, 2017). As a result of this, the Marine Corps officially re-designated it as the 1st Infantry Training Detachment and later as the Infantry Training Company (SOI-E, 2017).

In 1979 the Infantry Training Company shifted from an adhoc training organization to a formal schoolhouse called Infantry Training School (SOI-E, 2017). Training duration also saw considerable change during this period. With a narrower focus, infantry Marines now received extended periods of instruction on advanced level tactics, techniques and procedures (TTP); advanced weapons systems handling; and weapons employment lasting up to six weeks (SOI-E, 2017). These changes are of particular importance when considering today's current emphasis placed on specialty training.

By the end of the 1980s the Marine Corps re-designated the Infantry Training School to its current state, the SOI. The re-design brought forth three supporting establishments underneath the SOI's command: 1) Infantry Training Battalion (ITB), designed to train Marines with infantry MOSs in basic and enhanced infantry skills; 2) Marine Combat Training (MCT), designed to train non-infantry Marines in basic infantry fundamental; and 3) Advanced Infantry Training Battalion, designed to "develop infantry small unit leaders and provide advanced skills training through professional instructors in order to empower Marines for service throughout the Operating Forces" (Advanced Infantry Training Battalion East [AITB-E], 2017). In order to execute their responsibilities AITB established five separate training courses to better serve all infantry MOSs: Advanced Anti-Tank Missile Gunner Course, Advanced Assault Marine Course, Advanced Machine Gunner Course, Advanced Infantry Marine Course, and Advanced Mortarman Course.

Identifying training areas, establishing a formalized command structures, identifying training standards, and tailoring that training for infantry specialties are the steps the Marine Corps took to set the foundation for today's current environment. This structure enabled AITB to more effectively create the current AMC curriculum.

B. RENEWED EMPHASIS ON FIGHTING CONCEPT AND TRAINING

In 2003, the Marine Corps was heavily engaged in the war on terror in both Iraq and Afghanistan. Fighting an unconventional enemy who employed asymmetric tactics forced the Marine Corps to adapt its warfighting strategy and renew the small wars fighting concept. This change paved the way for increased operations at lower echelons where greater responsibility and decision-making was placed on the shoulders of small unit leaders, specifically squad and section leaders. In 2005, the Commandant of the Marine Corps, then General Michael W. Hagee, approved the Marine Corps distributed operations concept, solidifying the need to operate at lower levels in a distributed fashion. He states that distributed operations are an “approach that will create an advantage over an adversary through the deliberate use of separation and coordinated, interdependent, tactical actions enabled by increased access to functional support, as well as by enhanced combat capabilities at the small-unit level” (United States Marine Corps, 2005, p. I). This “enhanced combat capability” is the foundation for the Marines Corps renewed emphasis on its human capital and structural underlining’s for AITBs advanced training courses (United States Marine Corps, 2005, p. I).

In an effort to execute distributed operations the Marine Corps placed a renewed emphasis on training and developing their small unit leader community. From 2003 to 2016 every Commandant of the Marine Corps presented some form of planning guidance to bolster the combat capabilities of small unit leaders through focused efforts on “realistic training and education systems” (United States Marine Corps, 2008, p. 14). In order to execute this concept, General James F. Amos emphasized investing in the education of Non-Commissioned Officers (NCO) and junior Officers based on their increased responsibilities while deployed or in a garrison setting (35th Commandant of the Marine Corps, 2010, p. 9). In 2016, General Robert B. Neller built upon General Amos’ guidance and instructed the Marine Corps to ensure force readiness through the “quality and challenging nature of our training” (United States Marine Corps, 2016a, p. 6). In his guidance, he stipulates that “In all training, as in actual operations we will emphasize decentralizing authority and placing accountability down to the lowest level of leadership, to train as we fight” (United States Marine Corps, 2016a, p. 8). General Neller’s mandate links advanced training opportunities to the distributed operations concept. His vision adds an element of the realism to the Marine Corps formal training programs reinforcing General Hagee’s original statement to “Provide[s] junior leaders additional technical skills that will enable them to perform combat tasks normally accomplished at higher levels of command” (United States Marine Corps, 2005, p. V, VI). Providing this realistic and challenging advanced training opportunity rests with the instructors of each advanced level AITB course. To effectively fight future adversaries this training must increase our small unit leader’s technical proficiencies and decision-making abilities, ultimately building the organizations overall combat capacity.

The Marine Corps’ emphasis on effective and realistic training did not reside solely at the organizational level, but was reinforced by commanding generals at lower echelons throughout the Marine Expeditionary Forces (MEF). In September 2013, Major General Lawrence D. Nicholson, Commanding General, 1st Marine Division (1ST MARDIV), further emphasized small unit leader training to all his subordinate commanders. 1ST MARDIV Order 3501.1A (DIVO 3501.1A) (2013) directed commanding officers to ensure their platoon sergeants and squad/section leaders receive appropriate advanced level training and that those Marines “will complete their respective Infantry Unit Leaders and Advance Leader Course prior to deployment” (p. 1). DIVO 3501.1A (2013) served as a mechanism to “provide unit[s] with a more capable and effective combat leader” (p. 1). As training guidance trickled down from the highest levels of the Marine Corps AITB quickly experienced a surge in student attendance, specifically for AMC.

C. 0341 MILITARY OCCUPATION SPECIALTY

An infantry battalion’s three 60 mm mortar sections and 81 mm mortar platoon are composed of Marines with the primary MOS of 0341, Infantry Mortarman and range in rank from Private through Sergeant. Charged with “the tactical employment of the M224, 60 mm light mortar and M252, 81 mm medium mortar” these Marines provide “indirect fire in support of the rifle and Light Armor Reconnaissance (LAR) squad, platoon and companies as well as support the actions of infantry and LAR battalions” (United States Marine Corps, 2016b, p. 3–44). In order to accomplish this a Mortarman holds a variety of billets, to include: Ammunition Man, Gunner, Assistant Gunner, Recorder, Forward Observer (FO), and Plotter (United States Marine Corps, 2016b). Of particular importance are senior Mortarman with the rank of Corporal (E4) or Sergeant

(E5) fulfilling supervisory billets as Squad and Section Leaders. Derived from the Navy and Marine Corps (NAVMC) 3500.44C entitled “Infantry Training and Readiness Manual” (2016), a Squad Leader and Section Leader are responsible for “the tactical employment of the mortar system” and “in addition to supervising the emplacement, laying and firing of the mortar, the squad or section leader supervises all other unit activities” (p. 14-3, 14-5). Navy and Marine Corps, 3500.44C also requires Infantry Mortarman to be able to accomplish the following tasks:

1. Carries out the orders of the Mortar Section Leader or the unit Commander
2. Carries out the orders of the Weapons Platoon Commander
3. Trains the squad in the performance of tasks that training objectives
4. Trains the squad in the performance of tasks that support platoon training objectives
5. Trains the section in the performance of tasks that support section and/or platoon objectives
6. Maintains the condition, care, and economical use of assigned weapons and equipment.
7. Inspects the condition, care, and economical use of assigned weapons and equipment
8. Advises the commander on the discipline, appearance, control, conduct, technical and tactical employment, and welfare of the section
9. Assists the commander in conducting risk management
10. Supervises operator maintenance for the M224A1 Mortar
11. Supervises operator maintenance for the M252A2 81 mm mortar
12. Writes and issues combat orders
13. Controls mortar squad during occupation and displacement
14. Communicates using proper communication procedures with organic wired and wireless communication
15. Records all firing data
16. Responsible for development and adherence to safety-T data

17. Operates the compass

18. Assists the commander in conducting risk management

19. Directs casualty collection and evacuation for the section

20. Coordinates and supervises all logistical requirements for the section

21. Supervises protective measures to counteract the effects of nuclear, biological, and chemical contamination

22. Performs squad leader fire commands without a Fire Direction Center, utilizing a circular firing table and applying the LARS rule for corrections (Navy and Marine Corps, 2016, p. 14-3 – 14-5)

D. ADVANCED MORTARMAN COURSE

The mission of Advanced Mortarman Course is “To provide training and education to 0341s serving in the billet of mortar squad leader, section leader, Forward Observer, or a member of a Fire Direction Center.” (Infantry Unit Leaders Training Company West [IULTC-W], 2017). The endstate of this training provides Fleet Marine Forces (FMF) with “Highly trained professionals capable of leading and executing across the range of military operations.” (SOI-E, 2017). In order to accomplish this students attend one of two training schoolhouses falling under the command of AITB-E located at Marine Corps Base, Camp Geiger, North Carolina or AITB-W located at Marine Corps Base, Camp Pendleton, California. Each fiscal year these two commands execute four AMCs and train a combined total of roughly 1,000 Marines.

Armed with the responsibility to train and educate Marines on the proper employment and deconfliction of both the 60 mm or 81 mm mortar systems, AMC faces a challenging mandate. The training presented at AMC focuses on developing the Marines:

> 60 mm mortar core competencies; 81 mm mortar core competencies; war fighting and decision making; small unit training; advanced land navigation; communications; combat orders; fire support planning; combat reports; motorized operations; call for indirect fire; close air support; reconnaissance, selection, and occupation of a mortar position; advanced techniques for mortar lay; adjustment of mortar fire without a fire direction center; basic fire direction center techniques; advanced fire direction center techniques; mortar employment techniques; and the

lightweight handheld mortar ballistic computer. (Advanced Mortarman Course, 2016, p. I-1)

The course provides students with 410 hours of academic instruction spread across 38 training days. AMC instruction provides students with the necessary skills and doctrinal knowledge to operate in leadership positions. The curriculum is executed through a variety of formal lectures, practical application exercises, field training, and live fire exercises. At the conclusion of the course each student is evaluated during a field leadership evaluation (FLE) modeled around a tactical scenario (IULTC-W, 2017). Table 1 shows the number of hours devoted to each aspect of the course.

Table 1. Hours Spent on Each Training Evolution. Adapted from Advanced Mortarman Course (2016).

Outcome =	Training Evolution	Hours	Percentage of Total Hours
	Demonstration	30	0.073
	Field Firing Exercise	104	0.253
	Guided Discussion	1	0.002
	Homework	45	0.110
	Lecture	47.25	0.115
	Practical Application	110	0.268
	Tactical Decision Game	6	0.015
	Tactical Exercise Without Troops	2	0.005
	Performance Exam	63.5	0.155
	Written Examination	2	0.005
Total =		410.75	1.00

Notes: AMC West curriculum breakdown

In order to attend AMC, prospective students are first identified by their parent commands under the criteria of serving as or preparing to serve as a Squad or Section Leader. Screening, selecting, and preparing prospective students for AMC falls on the shoulders of the Marine's Company Commander. He is the individual directly responsible for ensuring each Marine meets the required demographic, physical and technical prerequisites for AMC. Specific requirements are delineated in both the AMC Period of Instruction (POI) and command screening checklist. From an individual perspective, potential students must be in an active or reserve status holding the rank of Corporal or Sergeant. Waivers are granted for Lance Corporals (E3) “when filling a Squad Leader billet” (Advanced Mortarman Course, 2016, p. I-2). The course also opens enrollment to both Officers and Staff Non Commissioned Officers (SNCO) on a space available basis.

From a physical perspective, potential students must meet Marine Corps height and weight standard and have a minimum PFT score of 135 or minimum CFT score of 190; based on seasonality of the testing period (Advanced Mortarman Course, 2016, p. I-2).

Finally, the Marine’s Company Commander must validate their technical skills from a “proficient” and “familiar” standpoint. Outlined in the AITB-W command screening checklist (2016), Marines must be proficient in “1) 60 mm mortar manipulation: mount a 60 mm mortar, small deflection, large deflection 2) 81 mm mortar manipulation: mount a 81 mm mortar, small deflection, large deflection refer realign, reciprocal lay, 3) lay a mortar with compass, and 4) boresight: boresight a 60 mm mortar, and boresight a 81 mm mortar.” Potential students must also be familiar with critical infantry tasks to include the orders process, operate a very high frequency (VHF) radio, execute tactical reporting, conduct call for fire (CFF), conduct close air support (CAS), and submit helicopter landing zone (HLZ) brief (Advanced Infantry Training Battalion, 2016).

Marines attending AMC execute a variety of physical, mental, and practical application evaluations throughout the 38-day course. AMC identifies three separate circumstances in which a Marine can be dropped from the course. They are 1) academic failure, 2) disciplinary failure and 3) other. As with many of the Marine Corps school houses, students must achieve a passing grade of 80 percent on required tests and evaluations. In the event a student does not reach this threshold they are granted a remediation period and two subsequent remediation attempts to achieve the minimum score. While remediating their deficiencies student must attend an academic review board to ascertain the reason for the failure. If deemed purely procedural or knowledge based (as opposed to a lack of effort) the student will be allowed to remediate his failure. If a student fails to meet the minimum score on their third remediation attempt they are automatically dis-enrolled from the course. Other disqualifying criteria include disciplinary failures for cheating or poor personal decisions outside the course schedule along with unforeseen circumstances (medical issues or personal complications).

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III. LITERATURE REVIEW

A. MARINE CORPS STUDIES

Training and educating small unit leaders to effectively lead and execute their duties can be a daunting task for any commander, especially when faced with compressed training timelines or limited school house quotas. As a result of this, commanders must take great care in identifying those Marines most capable of completing their basic or advanced level courses on the first attempt. It is not difficult to see a common trend in the type, nature, and methodology used in Marine Corps formal training environments. With similarities in how instruction is presented, trained to, tested, and remediated we can accurately translate key variables of success from one course to another while expecting similar results. The results from three Marine Corps studies outlines a potential starting point for my analysis. Previous research indicates that training success is predicated on a variety of predictive factors stemming from an individual's physical, cognitive or non-cognitive measure. Commanders who understand these factors will inevitably be able to better select Marines for advanced level training, which adheres to the Marine Corps' organizational guidance to provide advanced training for small unit leaders.

The use of cognitive predictive measures is hardly a new concept in the Marine Corps. Condit, Diamond and Turnbladh's 1956 study of Marine Corps training during World War II, explains the assignment and training process for specialty MOSs. They mention that "at the outset of the war, the Marine Corps had in effect a selection system based on three criteria: education, previous experience, and aptitude" (Condit, Diamond & Turnbladh, 1956, p. 207). The authors identify 30 percent of the Marine Corps specialty MOSs, to include Infantry Weapons, require characteristics associated with the "previous experience" and "mechanical aptitude" categories (p. 208).

In 1993, Captain Michael Snyder conducts an empirical analysis of student success at Marine Security Guard (MSG) School. His research focuses on identifying key variables in a Marine's Master File to better predict their probability of graduation. His analysis uses 1,794 observations throughout multiple MSG classes (Snyder, 1993, p. 47). Key variables used in Synder's research applicable to this study are education levels, PFT scores, rifle scores, TIS, TIG, ASVAB scores, and current age (Snyder, 1993, p. 47).

Using logistic regression models Snyder finds that PFT score, rifle score and GT scores are significant predictors of success at MSG School. He also finds other demographic factors of age, grade, race, and TIG as statistically significant (Snyder, 1993, p. 70.). Snyder's work is of particular importance when viewed against the Marine Corps' renewed emphasis on advanced level training for small unit leaders. Unlike previous studies, his thesis links the predictive power of individual characteristics to training course success vice future job performance, something of interest in this study.

Linking Snyder's research to the current day infantry community is the work by Captain Albert Nowicki. In his master thesis titled, United States Marine Corps Reconnaissance Course: Predictors of Success (2017), he furthers the research discussion by identifying specific physical, cognitive, and non-cognitive aspects increasing a Marine's overall probability of success at Basic Reconnaissance Course (BRC). Nowicki's findings validate Snyder's study and again identify PFT and GT scores as valid predictors of success. He finds that at the margin, students with a PFT score greater than 275 are 15.98 percent more likely to graduate BRC (Nowicki, 2017, p. 65). Through the use of a Cox Proportional Hazard model Nowicki identifies a one unit change in PFT score increase a student's probability of success by one percent (Nowicki, 2017, p. 65). Additionally, his findings indicate a positive correlation between graduation, a Marines GT score and level of post high school education. His findings on PFT scores are of particular importance because they demonstrate the magnitude at which physical fitness metrics play towards a Marine's success. These findings are important and can possibly translate to predicting graduation at AMC.

The final Marine Corps study analyzed in this review is from Captain Greg Jaunal's master thesis, titled: Leveraging Non-Cognitive Testing to Predict Success at USMC Scout Sniper School (2017). His empirical analysis studies predictive factors aiding in a Marine's success at Scout Sniper Basic course. Using Probit regression models to constrain the effect of his independent variables on the dependent variable (1 =

graduation and 0 = failure), Jaunal finds a Marine's PFT score, proficiency marks (PROs) along with components of their ASVAB test scores as statistically significant factors in predicting success (Jaunal, 2017, p. 36–37). While his work validates the assumptions proposed by Snyder and Nowicki, he does identify one negative relationship pertaining to graduation and the specific range in which a Marines PFT score falls. He identifies that Marines with a mid-level PFT score are associated with an overall decrease in their probability of graduation (Jaunal, 2017, p. 36). This finding indicates that while significant towards success a Marines' PFT score is most useful when associated with values closer to the upper tail. While still a valid predictor, this finding suggests additional scrutiny should be applied to each variable and categorical values should be considered for a better assessment. Based on its predictive strength I call out another statistically significant finding where Jaunal identifies that a Marine whose PRO markings fall below the population average of 4.4, will decrease "the probability of graduation by 19%" (Jaunal, 2017, p. 36). Used as a tool to assess technical proficiency this variable holds a high degree of economic significance. Jaunal also finds cognitive ability measured in the ASVAB subtest, Auto Shop (AS), is also a valid predictor of success. He proposes that technical familiarity and the use of tools aid in a Marine's ability to manipulate their "scope and optic" (Jaunal, 2017, p. 37). The importance of these findings indicates that advanced training courses require a variety of complex technical, physical, and cognitive abilities. Variable selection and model choice need to be carefully tailored based on the individual nature of the course requirements.

A critical component of Nowicki and Jaunal's work is the application of non-cognitive measures in their analyses. Analyzing both GRIT scale, defined by Jaunal (2017) as something that "seeks to determine an individual's desire to complete tasks over time" and components of the Big Five Personality traits, such as conscientiousness; we conclude that a Marine's success is further predicated on personality and character traits (p. 13). This research is of particular importance when analyzing advanced level training curriculums in an effort to determine if purely academic and performance evaluations are the main determinants of failure or if willingness and fortitude in the face of adversity have a play.

B. OTHER MILITARY STUDIES

After reviewing relevant literature on military training, one can quickly see a common thread amongst the findings. Linking and more importantly validating many of the researchers' studies is the use of ASVAB test scores as an effective predictor of success. In 1990, Paul Mayberry and Catherine Hiatt conduct a study on infantry job performance using ASVAB test scores as a baseline measurement tool. Their research focuses on assessing job performance as outlined by a previous joint service Job Performance Measurement (JPM) project, while incorporating additional cognitive testing predictors as supplements to the ASVAB test. Mayberry and Hiatt (1990) conclude, "The ASVAB does an excellent job of predicting a variety of infantry performance measures, hands-on-performance tests, written job knowledge tests, and infantry school training grades" (p. 24). Due to the marginal impacts of these supplemental tests, Mayberry and Hiatt (1990) conclude that larger gains are achievable by merely refining the current ASVAB test instead of creating a modified one (p. 26).

Validating the use of ASVAB test scores is the work by Driskell, Hogan, Salas, and Hoskin (1994) who analyze student success at Naval basic electricity and electronic (BE&E) training course. Similar to Mayberry and Hiatts work, their research focuses on using ASVAB test scores as a baseline measurement tool while applying additional personality predictors to better assess BE&E training performance. The findings reveal that the ASVAB subtest Mathematics Knowledge (MK), is the best predictor for academic performance (Driskell, Hogan, Salas, & Hoskin, 1994, p. 39). The authors continue to expound on the benefits of using the ASVAB test as a valid predictor stating, "Research indicates that training success can be predicted consistently with cognitive measures" but further elaborate on how characteristics such as "conscientiousness, ambition, and intellectual curiosity" also affect training success (Driskell, Hogan, Salas, & Hoskin, 1994, p. 44). The studies conducted by Mayberry and Hiatt coupled with the work done by Driskell, Hogan, Salas, and Hoskin provide insight into the applicability and usefulness of the ASVAB test. As identified, this cognitive measure is not the single source for predicting training success but merely serves as the most reliable variable available to the military.

IV. DATA AND METHODOLOGY

A. DATA SOURCES

I use two data sources in this study: school house data on mortarmen students collected from the AMC staff at AITB East and West, and general personnel data from the Marine Corps' master files, Total Force Database Warehouse (TFDW).

Schoolhouse data collection began at the source, the Advanced Infantry Training Battalion East and West staff responsible for administering the AMC. The AMC staff provided rosters of students spanning from FY 2013 through FY 2016. Both sets of rosters are broken into four class iterations per FY with an additional class iteration added in FY 2016 for AMC East. My empirical analysis recognizes variation in the level of detail with school house data. Due to archival issues, I am missing attendance rosters and graduation information for two AMC East classes in FY 2013 (3-13, 4-13) and one class in FY 2014 (1-14). TFDW's archival capabilities serve as the mechanism to correct for and obtain a master roster and graduation information for the missing classes.

School house data is organized into multiple databases divided between classes and year. The files contain students' Department of Defense (DOD) identification number, electronic data interchange personal identifier (EDIPI), name, rank, unit/ company, monitored command code (MCC), completion code, and/or completion date. This data provides the sample size and composition necessary to collect specifics on previous students.

The second and main source of data comes from Total Force Database Warehouse. TFDW is an organization that complies and archives 30 years of personnel data from multiple Marine Corps databases. Using consolidated AMC Excel files, I requested personnel data at two points in a Marine's career, the most recent snapshot prior to the course convene date and the snapshot on the last day of the course graduation month, covering three areas cognitive, performance, and experience. The ten TFDW files I use are listed in Table 2.

Table 2. TFDW File Descriptions.

Database =	File Name	Description
	BIR	Basic Individual Record information (proficiency and conduct markings, age, race, marital status, MOS, date of birth)
	CFT	Combat fitness test scores
	PFT	Physical fitness test scores
	RIFLE	Rifle qualification scores and class
	PISTOL	Pistol qualification scores and class
	SCHOOLS	Marines career school history
	DEPLOY	Deployment history, times, and locations
	UNIT	Unit history, locations, and duration
	MCRISS	Recruiting information (ASVAB scores and subcomponent test scores)
	EDUCATION	Civilian level education

B. DATA CLEANING AND MERGING

The first step I take is cleaning and merging all information into AMC master files for each coast. I use TFDW's BIR file to generate AMC West and SCHOOLS file to generate AMC East's masters. I chose these databases because they contain the most uniquely identifiable variables per observation when compared to the remaining nine databases. I remove all Marines who registered for a class but for unforeseen reasons did not attend. Finally, I remove any irrelevant historical or post-graduation month TFDW snapshots. This process is replicated on the remaining TFDW files. Once clean, I append each database to its associated master file.

I use unique identification variables class, dod_id, last_name, and first_name to match observations from both the master and using files. These variables allow for 95 percent accuracy between merges. With a consolidated master file, I give the observations randomly generated observations numbers and remove any personally identifiable information (PII).

C. SAMPLE

The sample consists of 1,217 enlisted Mortarman who attended AMC in FY 2013 through FY 2016. Each Mortarman is a unique observation specific to a class iteration and year group. Table 3 contains summary statistics for the variables used in this analysis. The sample consists of all males, primarily white (90 percent), averaging 22 years old. The largest portion of this sample is Lance Corporals, at 59 percent, followed by Corporals (Cpl), at 32 percent, and Sergeants (Sgt), at 9 percent. I exclude Officers and SCNOs from the analysis to better assess the primary enlisted training audience.

Cognitive and performance variables depicted in Table 3 are continuous in nature, each with an associated mean value measured against the entire sample. Experience variables corresponding to rank, TIG and unit duration are continuous in nature and have mean values measured against only those observations tied to each specific rank from the sample. Variables corresponding to rank, TIG and unit duration less than 18 months are binary in nature with mean values measured against the entire sample. Additionally, summary statistics indicate that prior to AMC, 38 percent of the sample have deployed at least once. Educationally, each Marine possesses a high school diploma or equivalent degree and a mere 5 percent of the sample have post high school experience.

Table 3. Summary Statistics.

Variable	Mean	Standard Deviation	Observations
DEPENDENT VARIABLE			
Graduated	0.71	0.45	1,217
COGNITIVE VARIABLE			
General Technical (GT) Score	106.54	10.34	1,217
PERFORMANCE VARIABLES			
PROCON	43.37	0.91	1,217
Rifle Qualification Class	3.66	0.60	1,217
Movement to Contact	258.47	30.67	1,217
Maneuver Under Fire	207.48	27.41	1,217
EXPERIENCE VARIABLES			
Age	22.23	2.39	1,217
Age: 21 and under	0.50	0.50	1,217
Lance Corporal	0.59	0.49	1,217
Corporal	0.32	0.47	1,217
Sergeant	0.09	0.28	1,217
White	0.90	0.30	1,217
Other race	0.10	0.30	1,217
Lance Corporal Time in Grade (months)	13.47	5.02	718
Lance Corporal Time in Grade > 18 Months	0.49	0.50	1,217
Corporal Time in Grade (months)	8.93	7.87	394
Corporal Time in Grade > 18 Months	0.28	0.45	1,217
Sergeant Time in Grade (months)	21.36	20.33	104
Sergeant Time in Grade > 18 Months	0.05	0.22	1,217
Lance Corporal Unit Duration (months)	17.40	5.27	719
Lance Corporal Unit Duration > 18 Months	0.32	0.47	1,217
Corporal Unit Duration (months)	24.59	13.02	394
Corporal Unit Duration > 18 Months	0.08	0.28	1,217
Sergeant Unit Duration (months)	23.45	20.83	104
Sergeant Unit Duration > 18 Months	0.04	0.20	1,217
Deployed in the past	0.38	0.48	1,217
Post High School Education	0.05	0.21	1,217

Notes: Data from TFDW. Observations from FY 2013 to FY 2016. Movement to contact and maneuver under fire times represented in mss.ms (e.g. mean of 2:58 seconds). I impute the mean rifle qualification score for missing observations and generate rifle qualification classifications accordingly to correct for data inconsistencies. Lance Corporal, Corporal, and Sergeant TIG and Unit Duration variables are measured against only those observations for each respective rank. Data inconsistencies account for 1 missing LCpl TIG (months) observation.

Next, I summarize in Figures 1 through 9 the sample's continuous variables to better understand their frequency and overall distribution. Figure 1 represents the samples age distribution, with Marines ranging from 19 to 33 years old. A Marine's composite number of deployments is depicted in Figure 2, which displays that the majority of the sample has never deployed. Figures 3 through 5 depict the distribution of rank as it applies to average TIG. Figure 6 represents the sample distribution in PROCON markings, ranging from 40 to 47. Distribution of GT scores are identified in Figure 7. Finally, movement to contact and maneuver under fire times are represented in Figures 8 and 9, with the X axis representing time, depicted in minutes, seconds format.

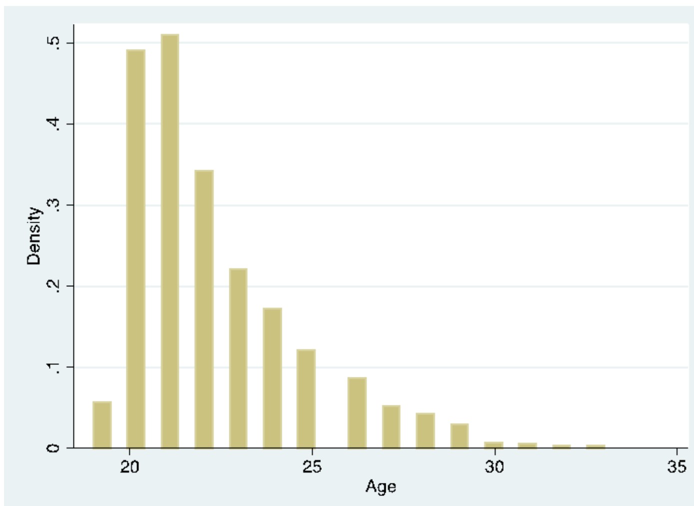

Figure 1. Age Distribution.

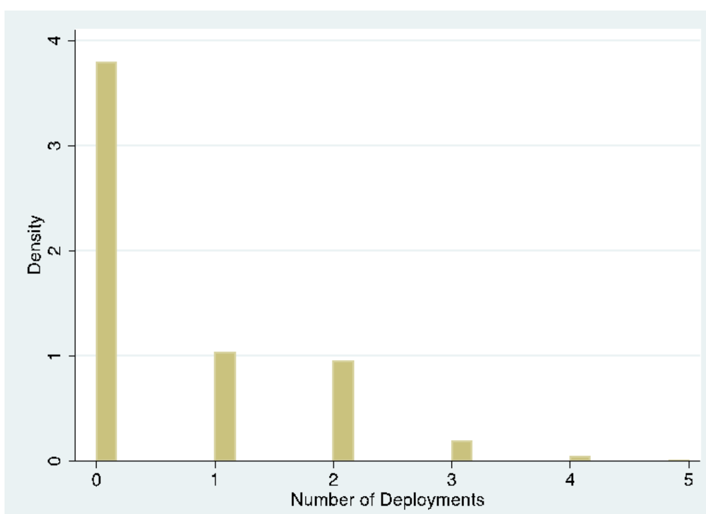

Figure 2. Number of Deployments Distribution.

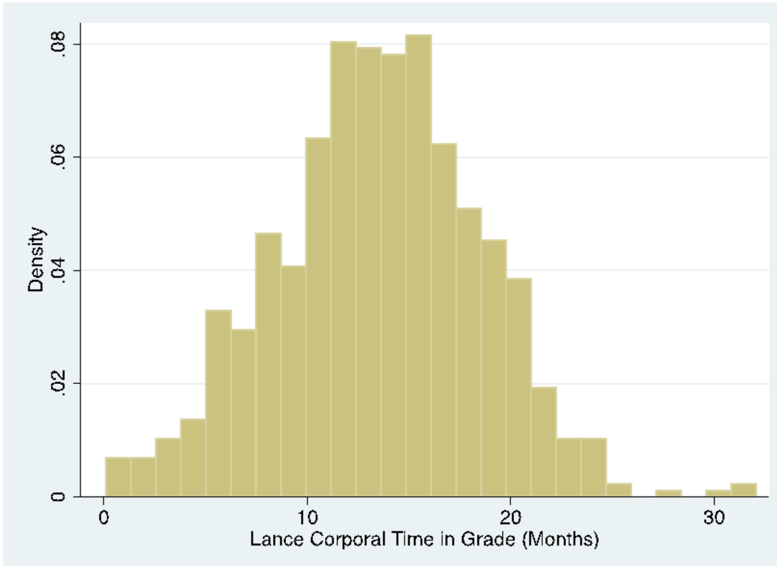

Figure 3. Lance Corporal TIG Distribution.

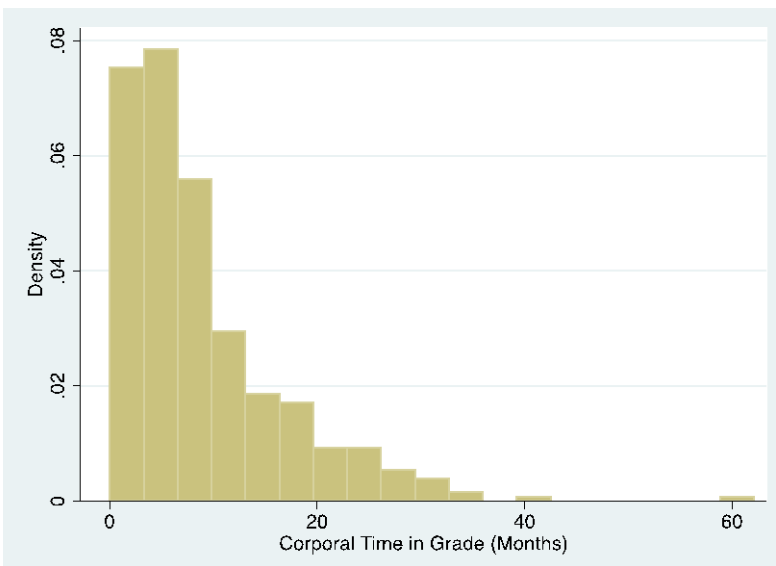

Figure 4. Corporal TIG Distribution.

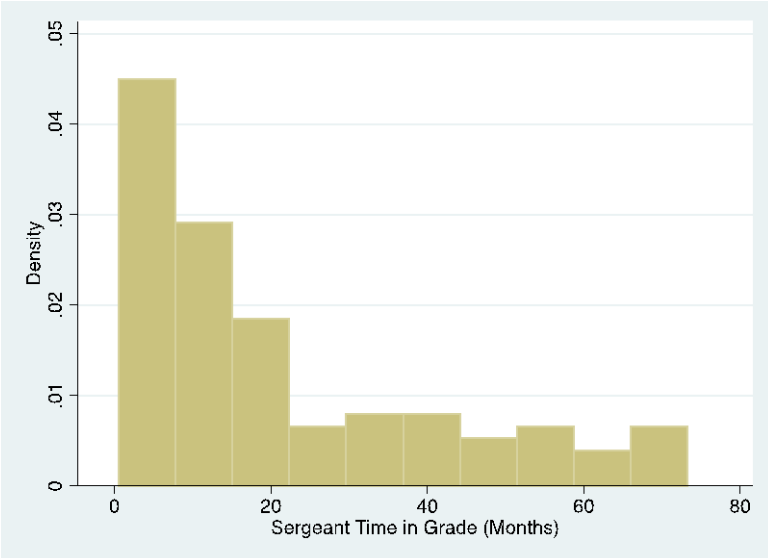

Figure 5. Sergeant TIG Distribution.

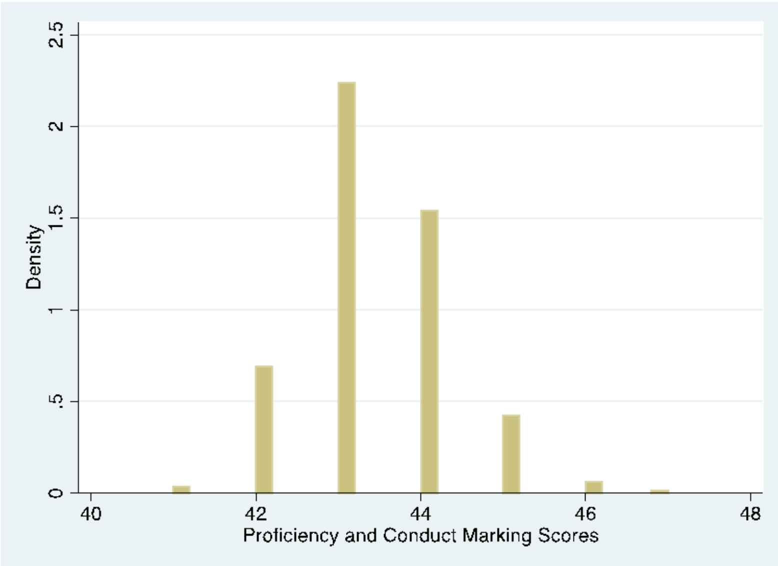

Figure 6. PROCON Distribution.

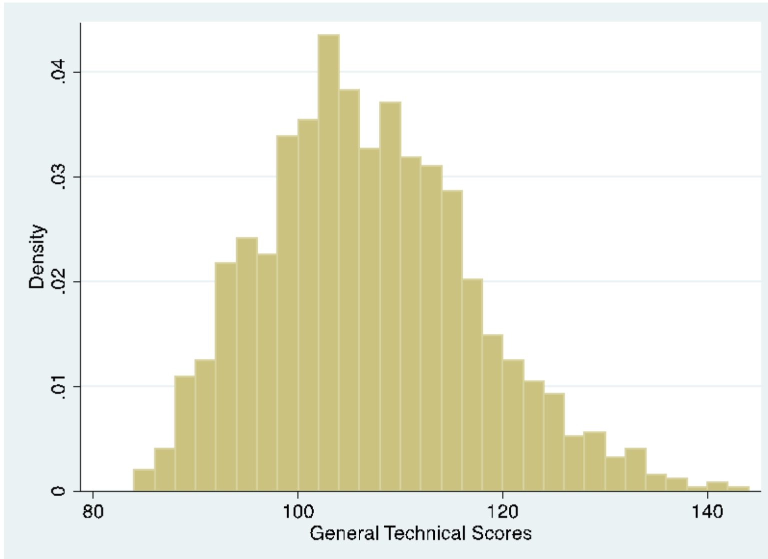

Figure 7. GT Distribution.

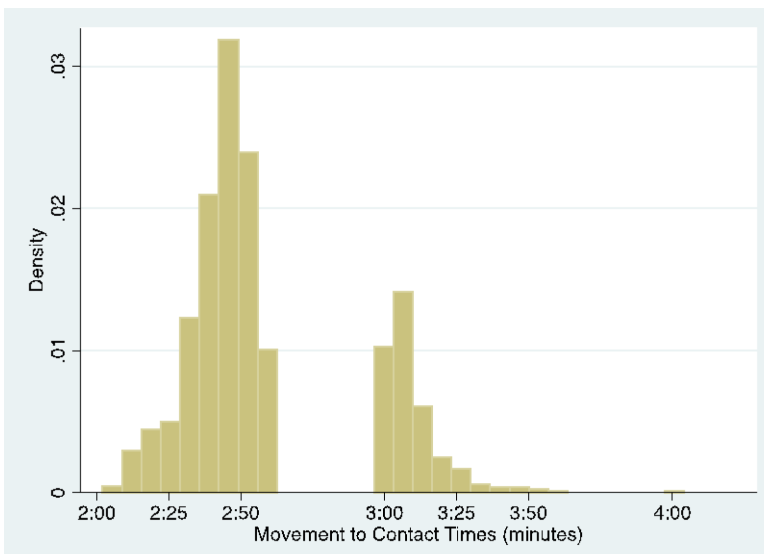

Figure 8. Movement to Contact Time Distribution.

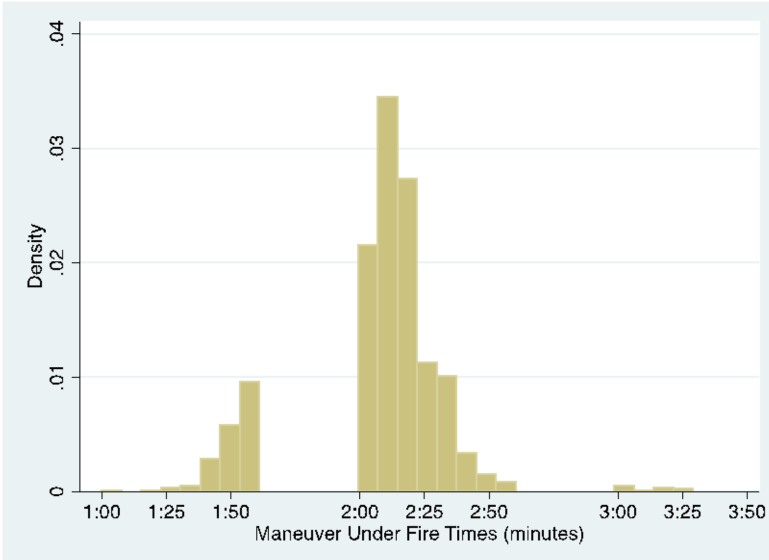

Figure 9. Maneuver under Fire Time Distribution.

Table 4 shows the cohort sizes for class year and iteration as well as graduation rates. In general, graduation rates have declined over time.

Table 4. Cohort Sizes and Graduation Rates at AMC, FY 2013–2016.

Outcome =	Class Iteration 1	Class Iteration 2	Class Iteration 3	Class Iteration 4	Class Iteration 5	Total
Class Year						
2013	0.86	0.88	0.95	0.77	--	0.87
	63	78	64	70		275
2014	0.88	0.79	0.81	0.58	--	0.77
	72	84	80	64		300
2015	0.64	0.79	0.59	0.61	--	0.66
	74	84	68	77		303
2016	0.69	0.52	0.56	0.65	0.49	0.59
	85	77	75	71	35	339
Total	0.76	0.75	0.72	0.65	0.49	0.71
	290	323	287	282	35	1217

Notes: 1,217 observations across four FYs. AMC East executed a non-required fifth class iteration in FY 2016.

D. VARIABLE CONSTRUCTION

I study two dependent variables related to graduation or failure from the course. The first is a binary indicator of graduating or not. The second is a continuous variable of the number of days a student lasted in the course; if a student graduated, this variable takes the value of 38 days, the length of the course.

The first variable category I consider in this analysis pertains to a Marine's cognitive abilities. I avoid omitted variable bias by creating a variable labeled GT to represent a Marine's mental dexterity or cognitive abilities. To generate GT scores, I sum two separate subtests from a Marine's Armed Forces Qualifying Test (AFQT): Arithmetic Reasoning (AR) and Verbal Expression (VE). This variable eliminates collinearity between using a Marine's composite AFQT score and any other subtests; which I exclude from this analysis. Wooldridge (2013) identifies that variables with measurement scales difficult to interpret are often best measured using standard deviations. I create a standardized GT variable using z-score by subtract the mean of GT and divide by its standard deviation (Wooldridge, 2013, p. 189). This variable is important in this analysis because it serves as a common Marine Corps recruiting and assessment tool that pairs intellectual levels with MOS selection.

I also look at other infantry MOSs and identify two specialties with minimum required scores greater than that of Mortarmen. To further analyze the effects of potentially increasing the minimum Mortarman GT score I create two separate dummy variables. The first is a GT score of 100 or greater, representing the minimum required for a Scout Snipers and the second is a GT score of 105 or greater, representing the minimum required for a Basic Reconnaissance Marines.

The second variable category in this study pertains to a Marine's individual and billet performance. The first variables I use are proficiency and conduct markings. Proficiency and conduct marks are an assessment tool measuring a Marine's overall job performance based on technical proficiency, reliability, and unit contribution. According to the Marine Corps' Individual Records Administration Manual (IRAM), a Marine can fall into three PROCON categories without negative implications; Average, with markings ranging from 40–44, excellent, with markings ranging from 45–48, and outstanding, with markings ranging from 48–50 (United States Marine Corps, 2000, p. 4–42) Sample data indicates that all Marines fall into the average or excellent category. To maintain an accurate picture of each Marine, more commonly referred to as the “whole Marine concept,” I generate one PROCON variable (United States Marine Corps, 2000, p. 4–42). I construct this variable by averaging a Marines’ proficiency in service and conduct in service markings. This technique enables me to reduce the correlation (rho value = .85) between each variable.

Another performance variable in this analysis is CFT score. The CFT serves as one of the Marine Corps primary physical fitness evaluations. Due to low variation in the sample’s composite CFT scores I discard this variable and focus the analysis on two of its three subcomponent scores; the movement to contact and maneuver under fire tests. From a theoretical standpoint, these subcomponents relate directly to a Mortarman’s ability to perform various assignments such as rapid movement to, establishing, and maintaining a mortar firing position.

The last performance variable I use in this study is rifle classification rating. This categorical variable links training tasks, such as the five crew drill steps or leveling the bubbles on the mortar system to individual characteristics such as fine motor skills (precision and hand-eye coordination), mathematical knowledge, and effectiveness in time constrained settings. I recode the four TFDW rifle classifications in sequential order ranging from the lowest (unqualified) to the highest (expert) with values from 1–4.

The third and final variable category I use contains data from Marines career experiences and individual demographics. I begin by viewing a Marine’s educational history and create a categorical variable to better assess the impact of having higher levels of civilian education. I consolidate the three advanced degree categories (one semester college, bachelors, and master’s degrees), and generate a dummy variable for post high school observations.

Next, I turn my focus to a Marine’s operational and career experiences in order to determine the impact of real world training, exercises, and operations on graduation likelihood. I asses a Marine's deployment history by analyzing TFDW's continuous variable number of deployments. I replace missing values with 0 to indicate a Marine has not conducted an operational deployment. With 62 percent of the sample not having a deployment, I focus on the binary indicator of having ever deployed.

Time in grade is another important indicator of experience. I generate this variable by subtracting the Marines individual course completion date from their present date of rank and divide by 30 days.

Wooldridge (2013) explains that "interaction terms allow for the partial effect of an explanatory variable to depend on the level of another variable." To better assess the relationship between rank and TIG I generate six interaction variables combining each rank into two categories, Marines with less than 18 months TIG and Marines with greater than 18 months TIG, displayed in Table 5.

Table 5. Time in Grade and Rank Interaction Variables.

	TIG	TIG <= 18 Months	TIG > 18 Months
Rank			
Lance Corporal		lcpl * tigls_18	lcpl * tiggt_18
Corporal		cpl * tigls_18	cpl * tiggt_18
Sergeant		sgt * tigls_18	sgt * tiggt_18

Finally, I seek answers regarding the impact unit duration has on graduation. To do this I create a continuous variable representing the total months a Marine spends with his operational unit prior to attending AMC. This variable helps identify whether or not unit time, which includes training exercises, training courses, and deployments are relative factors contributing to graduation. I generate this variable by subtracting a Marine's individual course convene date from their present unit join date and divide by 30 days.

Similar to TIG interactions, I seek effects of unit duration as it pertains to rank and generate interaction variables for LCpls, Cpls, and Sgts. A breakdown of the interaction variables is displayed in Table 6.

Table 6. Unit Duration and Rank Interaction Variables.

	Unit Duration	Unit Duration <= 18 Months	Unit Duration > 18 Months
Rank			
Lance Corporal		lcpl * unit_durls18	lcpl * unit_durgt18
Corporal		cpl * unit_durls18	cpl * unit_durgt18
Sergeant		sgt * unit_durls18	sgt * unit_durgt18

E. METHODOLOGY

The first step in my analysis involves a series of stepwise regression techniques to pinpoint the bivariate correlates of graduation. Then, I run a multiple regression of graduation on all the potential correlates, using the Linear Probability Model for ease of interpretation.

$$\begin{aligned} y = {} & \beta_0 + \beta_1 GT + \beta_2 PROCON + \beta_3 Rifle\_Class + \beta_4 Mtc\_tm + \beta_5 Manuf\_tm \\ & + \beta_6 Age_{19\_21} + \beta_7 Deploy_{1\_up} + \beta_8 LCpl + \beta_9 Cpl + \beta_{10} TIG_{ls\_18} + \beta_{11} LCpl_{TIGls\_18} \\ & \beta_{12} Cpl_{TIGls\_18} + \beta_{13} Unit\_Dur + \beta_{14} LCpl_{Unit\_Durls18} + \beta_{15} Cpl_{Unit\_Durls18} + \varepsilon \end{aligned}$$

Holding all other variables constant, the LPM explains that graduation y, is estimated on:

β_0 = the intercept

β_1 = change in the graduation likelihood with 1 unit change in GT score.

β_2 = change in graduation likelihood with 1 unit change in proficiency and conduct score.

β_3 = change in graduation likelihood with 1 unit change in rifle qualification classification.

β_4 = change in graduation likelihood with 1 unit change in movement to contact time.

β_5 = change in graduation likelihood with 1 unit change in maneuver under fire time.

β_6= change in graduation likelihood for Marines 21 years of age or younger.

β_7 = change in graduation likelihood for Marines with one or more number of operational deployments.

β_8 = change in graduation likelihood for Marines who are LCpls.

β_9 = change in graduation likelihood for Marines who are Cpls.

β_{10} = change in graduation likelihood for Marines with less than 18 months TIG.

β_{11} = change in graduation likelihood for LCpls with TIG less than 18 months TIG

β_{12} = change in graduation likelihood for Cpls with TIG less than 18 months TIG

β_{13} = change in graduation likelihood for Marines with unit durations less than 18 months.

β_{14} = change in graduation likelihood for LCpls with unit durations less than 18 months.

β_{15} = change in graduation likelihood for Cpls with unit durations less than 18 months.

ε = error term.

The incremental nature of AMCs curriculum requires Marines to master techniques and employ them in subsequent and more complex phases; raising the question of overall survivability. A Marine’s overall duration or as Wooldridge (2013) describes, “a variable that measures the time before a certain event occurs” is of particular importance in this analysis. I focus on duration by analyzing each Marine as they enter the initial state, or begin each course. I further observe the duration at which they exit the initial state. Exit criteria is a result of two reasons: 1) failure: academics, skills mastery, or other and 2) censored: completed the 38-day training cycle. I generate a training day variable by subtracting a Marine's class graduation date from their individual completion date and divide by 5/7. This provides me with a duration variable exclusive of weekend days that would increase the overall course length. I then subtract that number from 38. Marines with a value of 38 completed the course while any other value indicates the exact duration from convene date to time t, failure.

Survival probability is analyzed using a hazard function. I employ a Cox Proportional Hazard model in order to identify individual characteristics that increase a Marine's probability of survival in subsequent phases, given the Marine survived up to the start of that particular phase. The model provides the predicted hazard rate *h*, at each training day *t*, given the covariate *x*, for each observation *j*.

$$h(t \mid x_j) = h_0(t)\exp(x_j\beta)$$

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V. RESULTS AND ANALYSIS

A. STEPWISE ANALYSIS

I conduct stepwise regression using single and multivariate linear probability models to better identify and assess the impacts of each variable on graduation. I control for FE related to changes in class year and iteration in all models. I evaluate the predictive power of those variables associated with each category (cognitive, performance, and experience) mentioned in Chapter IV.

The first category of variables I analyze focuses on a Marine's cognitive abilities as measured in the ASVAB. Column 1 of Table 7, indicates that a one unit increase in overall GT score is roughly associated with a one percentage point increase in graduation likelihood. The predictive power of a Marine's GT score produces sizeable impacts when compared against the sample graduation mean of 0.71. Disaggregating GT into the 2 main sub-components, arithmetic reasoning and verbal expression, Column 2 shows that arithmetic reasoning, or the ability to execute mathematical word problems, is the stronger predictor of graduation. In particular, a 1 unit increase in arithmetic reasoning score is associated with a 1.4 percentage point rise in the likelihood of graduation, while a 1 unit increase in verbal expression score is only associated with a 0.4 percentage point increase.

I also standardize the ASVAB components, subtracting the mean and dividing by the standard deviation. Column 3 show that one standard deviation change in GT score increases a Marine's likelihood of graduation by 9.8 percentage points. Column 4 takes the same approach as Column 2 and breaks GT into its standardized subcomponents. The results are similar to earlier findings and reveal arithmetic reasoning to be the most influential predictor of graduation. Specifically, a change of one standard deviation in arithmetic reasoning contributes to a 9.2 percentage point increase in the likelihood of graduation, while a change of one standard deviation in verbal expression is only associated with a 2.3 percentage point increase. I also incorporate all ASVAB subcomponents into the regression to determine which variables are the strongest predictor of graduation, the findings are denoted in Column 5. Results reveal a strong shift in the predictive power of arithmetic reasoning, reducing its magnitude from 9.2 percentage points to 4 percentage points when variable mathematical knowledge is included. Mathematical knowledge is now the strongest predictor, associating a one unit change in standard deviation to increasing the likelihood of graduation by 9 percentage points (p<.01).

Table 7. Cognitive Variables, Stepwise Regressions.

Outcome =	Graduated	Graduated	Graduated	Graduated	Graduated
	(1)	(2)	(3)	(4)	(5)
General Technical Score (gt)	0.009***				
	(0.001)				
Arithmetic Reasoning (ar)		0.014***			
		(0.002)			
Verbal Expression (ve)		0.004*			
		(0.002)			
General Technical Score (gt), standardized			0.098***		
			(0.012)		
Arithmetic Reasoning (ar), standardized				0.092***	0.04**
				(0.013)	(0.02)
Verbal Expression (ve), standardized				0.023*	0.03
				(0.013)	(0.02)
Math Knowledge (mk), standardized					0.09***
					(0.02)
Clerical (cl), standardized					-0.02
					(0.02)
Electronic Information (ei), standardized					0.01
					(0.02)
General Science (gs), standardized					-0.01
					(0.02)
Mechanical Comprehension (mc), standardized					-0.00
					(0.02)
Auto Shop (as), standardized					0.05***
					(0.02)
Observations	1,217	1,217	1,217	1,217	1,217

Notes: Data from TDFW's MCRISS data file. GT score is sum of AR and VE subtests. Fixed effects included to control for class year and class iterations.

*** p<0.01, ** p<0.05, * p<0.1

The second category of variables I analyze focuses on a Marine's performance during annual tests and semi-annual evaluations. I use univariate regressions to compare variables listed in Columns 1–5 of Table 8 against graduation. Results in Column 1 indicates PROCON markings as a significant predictor and associate a one unit change to an 11.5 percentage point increase in the likelihood of graduation ($p<.01$). Column 2 displays the predictive strengths of each of the two PROCON subcomponent, proficiency markings and conduct markings. The table reveals proficiency markings as the strongest predictive variable of graduation. In particular, a 1 unit increase in proficiency score is associated with an 8.5 percentage point rise in the likelihood of graduation, while the remaining subcomponent, conduct markings, is statistically insignificant. Additionally, I analyze the predictive power of PROCON categories on graduation, applying it to an increase from the “average” PROCON category, with markings ranging from 40–44 to the “excellent” PROCON category, with markings ranging from 45–48 (United States Marine Corps, 2000, p. 4–43). This translates to a Marine moving into the top 90 - 95th percentile for the sample. Findings point to a 14.5 percentage points rise in the likelihood of graduation for those Marines receiving excellent PROCON markings. When compared against the mean graduation rate of .71 this implies a 20.4 percent increase in their chance of graduating.

Using a univariate regression, I find that a Marine’s rifle qualification classification is statistically insignificant and not a valid predictor of graduation. Table 8 also shows that physical characteristics have minimal predictive power on the likelihood of graduation. Column 5 of Table 8, shows that a Marine’s composite CFT score is not considered statistically significant. However, disaggregating CFT score into its three main sub-components, movement to contact, ammo can lift, and maneuver under fire, I find a negative relationship, albeit with minimal predictive strength between movement to contact time and graduation. Column 6 shows a that a one unit increase in movement to contact time is associated with a 0.1 percentage point decrease in the likelihood of graduation ($p<.1$). I remove ammo can lift scores from the analysis in Column 7 due to limited variation in the data, which reveals no impact on the predictive strength of the other two variables.

Table 8. Performance Variables, Stepwise Regressions.

Outcome =	Graduated	Graduated	Graduated	Graduated	Graduated	Graduated	Graduated	Graduated
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
PROCON	0.115***							
	(0.014)							
Proficiency Marking (Average in Service)		0.085***						
		(0.026)						
Conduct Marking (Average in Service)		0.037						
		(0.025)						
PROCON Excellent			0.145***					
			-0.042					
Rifle Qualification Class				0.026				
				(0.021)				
CFT Composite Score					0.002			
					(0.002)			
Movement to Contact						-0.001*	-0.001*	
						(0.000)	(0.000)	
Ammo Can Lifts						-0.002		
						(0.002)		
Maneuver Under Fire						0.000	0.000	-0.000
						(0.000)	(0.000)	(0.000)
Observations	1,217	1,211	1,217	1,217	1,217	1,217	1,217	1,217

Notes: 6 observations were hard coded, giving PROCON 1,217 observations. The subcomponents were not hard coded and are missing data. This amount of missing data points is small enough and will not skew the regressions. Fixed effects included to control for class year and class iterations.
*** p<0.01, ** p<0.05, * p<0.1

The third category of variables I analyze describe a Marine's experiences and demographics. Column 2 of Table 9 indicates that the number of deployments are a significant predictor of graduation. In particular, a Marine that has been deployed one or more times has a 3.4 percentage point lower likelihood of graduation (p<.05) than a Marine who has never been deployed. I highlight the importance of this variable as its predictive power substantially increase in future analyses.

I also focus on the predictive power of a Marine's rank and break the sample into its three main categories, LCpls, Cpls, and Sgts; Sgts serving as the base. Column 4 suggests that when separate of other variables, rank is not statistically significant. An important discovery is the changes in rank coefficients when TIG is introduced to the multivariate models. Column 5 reveals a substantial change in the predictive nature of LCpls with less than 18 months TIG. Findings indicate that LCpls with less than 18 months TIG are 19.8 percentage points less likely to graduate (p<.05). The last finding in Table 9 is identified in Column 6, and indicates that rank and unit duration are statistically insignificant predictors of graduation.

Table 9. Experience Variables, Stepwise Regressions.

Outcome =	Graduated	Graduated	Graduated	Graduated	Graduated	Graduated
	(1)	(2)	(3)	(4)	(5)	(6)
Age: 21 and Under	-0.038					
	(0.025)					
Number of Deployments		-0.034**				
		(0.014)				
Post High School Education			0.056			
			(0.059)			
Lance Corporal				-0.063	0.077	-0.053
				(0.046)	(0.078)	(0.066)
Corporal				0.006	0.028	0.008
				(0.048)	(0.092)	(0.066)
TIG < 18 Months					0.102	
					(0.087)	
Lance Corporal TIG < 18 Months					-0.198**	
					(0.097)	
Corporal TIG < 18 Months					-0.057	
					(0.110)	
Unit Duration < 18 Months						-0.012
						(0.086)
Lance Corporal x Unit Duration < 18 Months						-0.019
						(0.092)
Corporal x Unit Duration < 18 Months						-0.020
						(0.100)
Observations	1,217	1,217	1,217	1,217	1,217	1,217

Notes: TDFW - MCRISS data, sample includes all observations. Sergeants are the control group. Class Year 2013 is the base year. Fixed effects included to control for class year and class iterations.

*** p<0.01, ** p<0.05, * p<0.1

B. MULTIVARIATE ANALYSIS

I develop a final LPM by regressing those statistically significant predictors identified in the stepwise analysis into one single model. I begin by regressing all variables together, excluding TIG and unit duration as denoted in Column 1 of Table 10. The results and magnitude of each predictor are fairly similar to earlier findings, with one noticeable change in the predictive strength associated with the number of deployments variable. In particular, a Marine with one or more deployment is now associated with an 9.9 percentage points decrease in their likelihood of graduation, ultimately increasing the failure amount from previous regressions by 6 percentage points (p<.01).

Columns 2 and 3 of Table 10 include TIG and unit duration into the regressions. Minor changes associated with the GT and number of deployment coefficients are depicted in Column 2. Additionally, LCpls with less than 18 months TIG are associated with a 20.1 percentage point decrease in their likelihood of graduation ($p<.05$). Column 3 of Table 10 indicates that the inclusion of a Marine's unit duration has minimal effects on the predictive power of each significant variable.

The final LPM I use in this study is depicted in Columns 4 which accounts for all variables while controlling for class FEs. Significant variables in Column 4 are GT, PROCON, movement to contact, number of deployments, and LCpls with less than 18 months TIG. For GT score, a one unit increase is associated with roughly one percentage point increase in the likelihood of graduation ($p<.01$). To better understand the context of this variable a Marine scoring 10 points higher on their GT score (e.g., mean of 106, Marine scoring 116) is 8 percentage points more likely to graduate. With a mean graduation rate of 0.71, a 10-point increase in score increases the Marine's likelihood of graduation by 11.3 percent. The model suggests a minimal increase in PROCON strength from earlier analyses, associating a 10.4 percentage point rise in the likelihood of graduation ($p<.01$). For example, the magnitude of this coefficient suggests that when a Marine increases their average PROCON markings from 44 to 45 there is a 14.6 percent increase in the chance of graduation.

Table 10. Linear Probability Model Regression.

	LPM w/FE	LPM w/FE	LPM w/FE	LPM w/FE
Outcome =	Graduated	Graduated	Graduated	Graduated
	(1)	(2)	(3)	(4)
General Technical Score (gt)	0.009***	0.008***	0.009***	0.008***
	(0.001)	(0.001)	(0.001)	(0.001)
PROCON	0.102***	0.102***	0.103***	0.104***
	(0.015)	(0.015)	(0.015)	(0.015)
Rifle Qualification Class	-0.001	0.002	-0.000	0.001
	(0.020)	(0.020)	(0.020)	(0.020)
Movement to Contact	-0.001*	-0.001*	-0.001*	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)
Maneuver Under Fire	0.001	0.001	0.001	0.001
	(0.000)	(0.000)	(0.000)	(0.000)
Age < 21	0.019	0.021	0.019	0.021
	(0.027)	(0.027)	(0.027)	(0.027)
Deployments > 1	-0.099***	-0.101***	-0.107***	-0.107***
	(0.026)	(0.026)	(0.026)	(0.026)
Lance Corporal	-0.056	0.079	-0.035	0.107
	(0.051)	(0.079)	(0.068)	(0.100)
Corporal	-0.023	0.058	-0.026	0.086
	(0.048)	(0.088)	(0.065)	(0.109)
TIG < 18 Months		0.134		0.144
		(0.084)		(0.088)
Lance Corporal TIG < 18 Months		-0.201**		-0.189*
		(0.093)		(0.098)
Corporal TIG < 18 Months		-0.134		-0.146
		(0.105)		(0.109)
Unit Duration > 18 Months			-0.020	0.025
			(0.081)	(0.086)
Lance Corporal Unit Duration < 18 Months			-0.042	-0.077
			(0.087)	(0.092)
Corporal Unit Duration < 18 Months			-0.013	-0.059
			(0.095)	(0.099)
Observations	1,217	1,217	1,217	1,217

Notes: Fixed effects included in column 1 - 4 to control for class year and class iterations.
Column 6 does not include FE.
*** p<0.01, ** p<0.05, * p<0.1

While movement to contact is a statistically significant predictor the magnitude of its coefficient, -0.001 suggests minimal theoretical impacts on graduation and again represents minimal changes from earlier analyses. Similarly, Column 4 indicates that the impact of a Marine's number of deployments remains fairly constant from previous analyses. The coefficient, -0.107, signifies that a Marine with one or more deployments is 10.7 percentage points less likely to graduate AMC ($p<0.01$). I hypothesize this negative relationship is predicated upon variations in training methodologies and doctrinal concepts inherent with a Mortarman's time and experience on deployments. Junior Marines have limited opportunities to interact in a formal school setting and on deployment potential exists to develop habits that stray from doctrine. In essence, this learning has the ability to generate poor behavior habits and muscle memory; clashing with established standards taught and evaluated at AMC. The final statistically significant variable is LCpls with less than 18 months TIG, showing a 18.9 percentage point decrease in overall graduation likelihood. This translates to a junior LCpl being 26.6 percent less likely to graduate. The remaining variables in Column 4 of Table 10 fall outside the range of statistical significance, having a $p>.1$.

C. SURVIVAL ANALYSIS

I use a Cox Proportional Hazard model and simultaneously assess the magnitude each covariate plays on a Marine's rate of survival during the 38-day course. The first step in I take in this analysis is identify the time in which each Marine attrite or are censored out. Training day, frequency of attrition, and percentage of the sample censored out are depicted in Table 11. One limitation with this analysis is variations in course schedules between coasts and class years. To correct for schedule variance, I use recent course schedules and categorize events into four separate blocks, linking the most significant evaluations to a range of training days. The first block, training days 1–4, account for failures related to mortar system core competency evaluations and land navigation evaluations. The second block, training days 7–18, account for failures related to basic FDC evaluations. The third block, training days 21–27, account for failures related to advanced FDC evaluations, while the fourth block, training days 30–34, account for failures related to course final evaluations and live fire field exercises (N. Leeds & K. Jensen, emails to author, May 25, 2017, and October 18, 2017).

Table 11. Survival Analysis Statistics: Attrition Frequencies and Percentage.

Survival Analysis - Attrition Statistics

Training Day	Frequency of Attrition	Percentage	
1	0	0.00	
2	6	0.5	Block 1
3	1	0.08	
4	2	0.17	
5	0	0.00	
6	0	0.00	
7	18	1.49	
8	2	0.17	
9	10	0.83	
10	10	0.83	
11	7	0.58	
12	19	1.57	Block 2
13	9	0.74	
14	6	0.5	
15	8	0.66	
16	2	0.17	
17	17	1.41	
18	12	0.99	
19	9	0.74	
20	4	0.33	
21	24	1.99	
22	44	3.64	
23	5	0.41	
24	31	2.56	Block 3
25	6	0.5	
26	17	1.41	
27	15	1.24	
28	8	0.66	
29	7	0.58	
30	10	0.83	
31	5	0.41	
32	5	0.41	Block 4
33	9	0.74	
34	0	0.00	
35	1	0.08	
36	4	0.33	
37	1	0.08	
38	875	72.37	
Total	1,209	100	

Notes: Data inconsistencies account for 8 missing observations

Limited variation in the mean PROCON scores for each failure on each training day force me to generate a binary variable to better assess PROCONs overall probability of failure. I generate a binary variable to categorize Marines with the sample mean PROCON score or below against those with higher scores.

Results from the Cox Proportional Hazard analysis depicted in Table 12 suggest that GT scores, PROCON markings, movement to contact times, number of deployments, and LCpls with less than 18 months TIG are meaningful predictors impacting Marines probability of survival.

The most significant covariate predicting survival at AMC is PROCON markings, suggesting that those with a PROCON marking of 43 or lower are 49 percent more likely to fail than those with a higher marking ($p<.01$). The second most influential covariate is LCpls with less than 18 months TIG, showing that on average, a LCpl with less than 18 months TIG is 44 percent more likely to fail than those with greater than 18 months ($p<.1$). The third most substantial covariate is number of deployments, indicating that a Marine with 1 or more deployment increases their probability of failure by 27 percent. GT score is the final covariate attributing to a Marine’s probability of failure at AMC. Findings indicate that a Marine with a 1 unit increase in GT score is 4.7 percent less likely to fail AMC ($p<.01$). I also find the covariate movement to contact as statistically significant, although it’s hazard ratio suggests minimal impact on the probability of graduation. Results show that a Marine with a 1 unit increase in movement to contact time (a 1 second increase in raw score time) is .4 percent more likely to fail ($p<.1$).

Table 12. Survival Analysis Regression.

	Cox Prop. Haz.
Outcome =	Training Day Attrite
	(1)
	Hazard Ratio
General Technical Score (gt)	0.953***
	(0.006)
PROCON <= Mean of 43	2.485***
	(0.354)
Rifle Qualification Class	1.017
	(0.088)
Movement to Contact	1.004*
	(0.002)
Maneuver Under Fire	0.997
	(0.002)
Age < 21	1.051
	(0.131)
Deployments > 1	1.274**
	(0.146)
Lance Corporal	0.588
	(0.297)
Corporal	0.689
	(0.372)
TIG < 18 Months	0.581
	(0.256)
Lance Corporal TIG < 18 Months	2.438*
	(1.201)
Corporal TIG < 18 Months	2.042
	(1.104)
Unit Duration > 18 Months	1.108
	(0.483)
Lance Corporal Unit Duration < 18 Months	1.103
	(0.506)
Corporal Unit Duration < 18 Months	0.914
	(0.452)
Observations	1,209

Notes: I use a Cox Prop. Hazard model. Graduates are censored out at 38 days. Data inconsistencies account for 8 observations missing attrition or graduation dates. PROCON is a binary variable representing Marines with a 43 marking or below.
*** p<0.01, ** p<0.05, * p<0.1

Figure 10 graphs PROCON survival rates across each training day. The upper bound is the survival rate for Marines with markings higher than the sample mean of 43, while the lower bound represents the survival for Marines at or below the mean score. Figure 10 reflects PROCONs survival qualities, attributing higher PROCON scores to a greater likelihood of survival, especially during training blocks 2 (training day 7–18) and block 3 (training day 21–27).

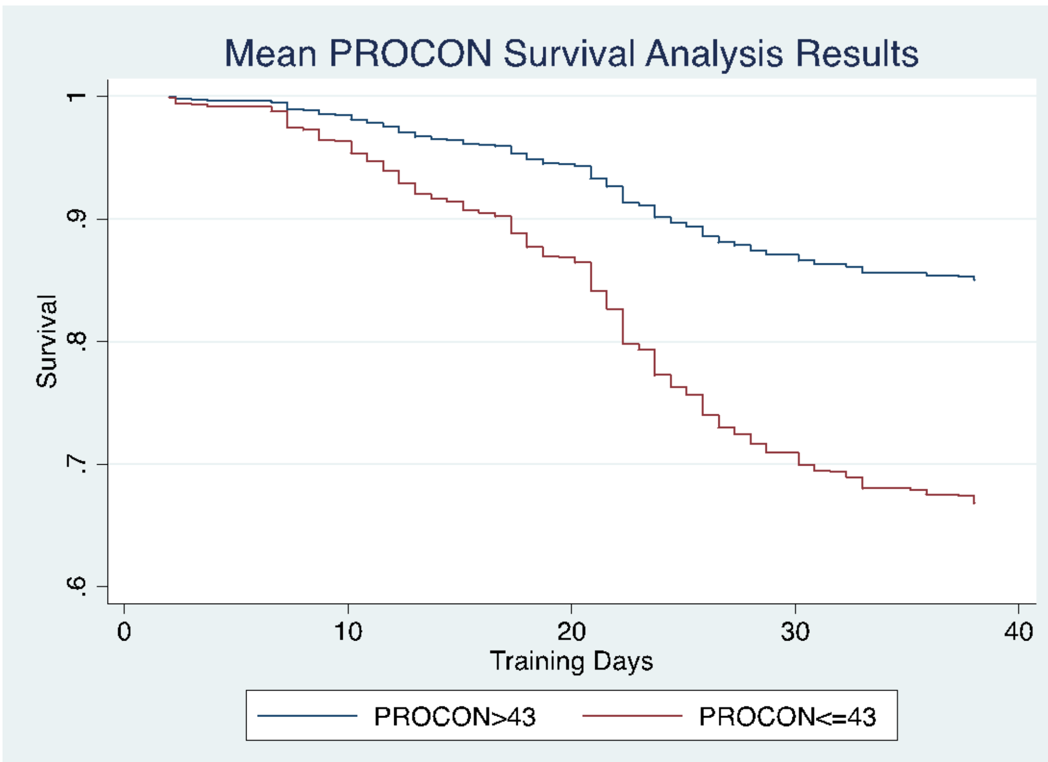

Figure 10. Mean PROCON Markings, Survival Analysis Results.

Figure 11 graphs GT survival rates across each training day. The upper bound is the survival rate for Marines with a GT score of 110, the minimum to be an officer. The lower bound indicates the required minimum GT score for Mortarman, 80. The remaining rates highlight other similar infantry MOS minimum scores. Figure 11 reflects similar survival qualities as PROCONs, attributing higher GT scores to a greater likelihood of survival, especially during block 2 (training day 7–18) and block 3 (training day 21–27).

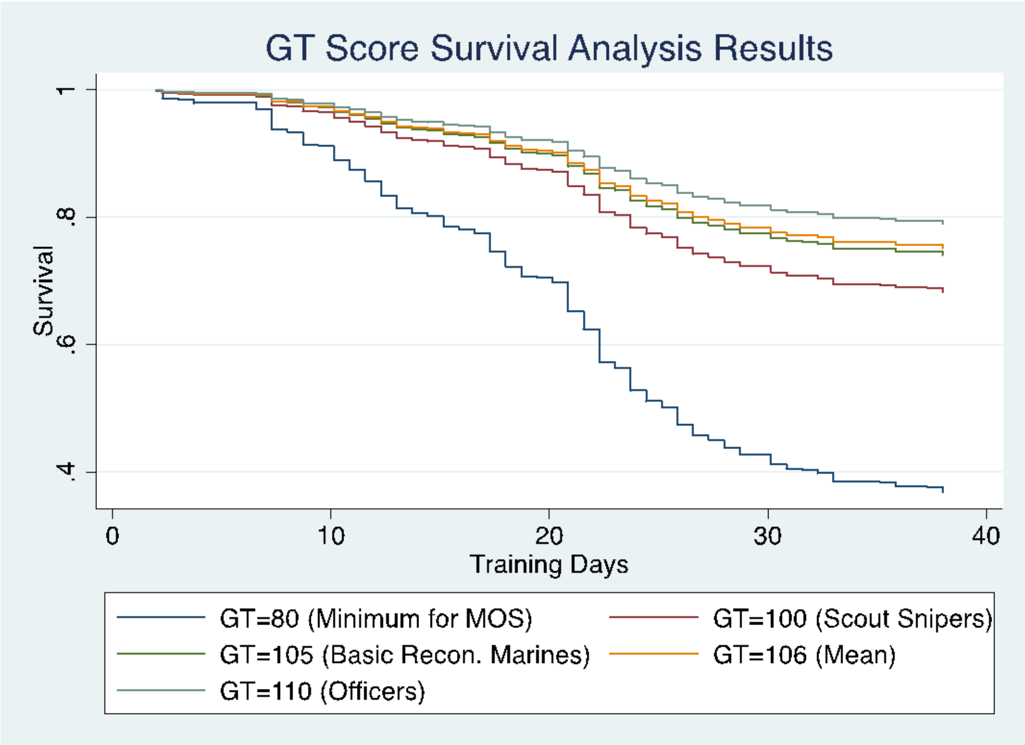

Figure 11. GT Score, Survival Analysis Results.

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VI. CONCLUSION AND RECOMMENDATIONS

The purpose of this study is to determine if a Marine's personal attributes and career experiences are meaningful predictors of success at AMC. I conduct regression analyses using empirical data to identify those characteristics affecting graduation in an effort to lower school house attrition rates, reduce personnel costs, and save time and physical resources. Additionally, this study provides insight to operational commanders and assists them in making better informed decisions during their screening and selection process. The benefit to increasing the rigors of the selection and screening process is to ensure prospective students are more likely to complete the training on their first attempt. Timely success at AMC translates to additional opportunities for small unit leaders to train, develop, and employ their advanced skills with their units. This will ultimately increase the units overall tactical proficiency and combat readiness.

As literature suggests, cognitive abilities represented in a Marine's ASVAB test scores are valid predictors of success during military training. My first finding further supports previous research and highlights the magnitude of GT scores on the probability of survival. This study's findings coincide with findings from Diskell et. al's research and identify ASVAB subcomponents to be key measures of effectiveness in military training. Again, this study's survival analysis further emphasizes that increased levels of cognitive ability have more of an impact impacts on a Marines probability of survival during difficult training phases, to include FDC and advanced FDC evaluations. These events require a heightened degree of cognitive agility and test a Marine's skill in generating accurate firing data using mathematical computations, elevation and distance computations, map reading, general cognitive processing speed, and precision.

In response to the GT score findings, I recommend additional research be conducted on changing the current Marine Corps policy regarding the minimum required GT score of 80. Research should focus on the effects of increasing the minimum score against the entire 0341 population. Identifying the population mean will help establish a new, suitable minimum threshold. Recommendations for potential thresholds can be based around other infantry MOSs, such as Scout Snipers, requiring a minimum score of 100 or even Basic Reconnaissance Marines, requiring a non-waiverable score of 105.

My second finding indicates PROCON marking is a statistically and economically significant predictor. In the operating forces, technically competent and tactically capable Marines traditionally have higher PROCON marks, which according to these findings directly affect a Marine's mastery of the course material, ultimately increasing their likelihood of graduation. Additionally, results from this study's survival analysis indicates that a Marine with a PROCON marking at or below the sample mean is more likely to fail than those above the mean. The survival analysis results further support previous research identified by Janual in Chapter III. To ensure the most technically competent Marines attend AMC, I recommend adding a minimum PROCON marking to the course prerequisites to ensure the most qualified and technically savvy Marines attend AMC. Marines with the greatest likelihood of graduation are those who possess an average PROCON marking of 44 or above. Future research should focus on the validity and standardization of a Marine's PROCON markings in an effort to more accurately assess a suitable threshold for each target audience category.

Advanced Mortarman Course (2016) describes their target population as "A Marine Mortarman (0341) Corporal or Sergeant Squad Leader." They also reinforce the composition of their target population under the prerequisite sections, however, they accept waivers, stipulating that "Lance Corporals may attend when filling a squad leader billet" (p. I-2). Sample analysis reveals that while AMCs intended target audience should be senior Mortarman, they are in fact, composed primarily of LCpls, accounting for 58 percent of the sample.

My third finding links the high numbers of LCpls in the sample, with the predictive power of TIG. As data reveals LCpls with less than 18 months TIG are at a higher risk of failure than those with more than 18 months. I recommend changing the current prerequisite policy to include a provision granting admission to only those LCpls with a minimum of 18 months TIG. Deferment allows operational units to better prepare and guide their small unit leaders in the execution of their duties. It also provides them with additional time and experience operating their designated mortar systems, presumably increased technical and proficiency levels.

Results from this study reinforce many of the findings in the wider body of literature linking key determinants of success to a variety of military training schools. The greater majority of previous research identifies that GT scores, PROCON markings, physical fitness metrics and rifle scores are meaningful predictors of success. This study shows similar results across many of these variables, however, it highlights the difference in predictive power associated with Marine Corps standardized physical and performance metrics (CFT and rifle scores). AMC relies heavily on cognitive and MOS technical proficiency, which are elements operational commanders can use to better screen and select future candidates.

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